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RESEARCH ARTICLE

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AN INVESTIGATION ON STRENGTH CHARACTERISTICS OF BASALT FIBRE REINFORCED CONCRETE

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ABSTRACT

The main objective of this experimental work is to investigate the behaviour of basalt fibre (chopped strand) reinforced concrete in which the fibres are added from 0% to 2.5% with 0.50% increments. The different strength characteristics studied are, compressive strength, tensile strength, flexural strength, shear strength and impact strength. A design mix of M30 is prepared by using the IS 10262:2009. 28 days water curing is adopted for all the testing specimens. Strength characteristics of basalt fibre reinforced concrete are compared with the reference mix (M30 concrete without fibre). From the experimental work, it can be concluded that the use of 2% basalt fibres in concrete shows significant increase in strength of the concrete especially in flexural and impact strength.

Keywords: Basalt fibre reinforced concrete, compressive strength, tensile strength, flexural strength, shear strength, impact strength.

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INTRODUCTION

The use of fibres in concrete has a long history of about 3000 years. In recent time different types of fibres are used in the concrete mix for various purposes such as asbestos, cellulose, steel, polypropylene and glass. These are introduced to increase some properties of concrete and to increase durability.

Basalt is a volcanic igneous rock which performs well in terms of strength, temperature range and durability. Basalt fibres are obtained from basalt rocks through the melting process called Junker's technology. The basalt fibres do not contain any other additives, which make additional advantage in cost. It is known that the basalt fibres have better tensile strength than the E- glass fibres, greater failure strain than the carbon fibres as well as good resistance to chemical attack, impact load and fire resistance.

Basalt fibre is a material made from extremely fine fibres of basalt, which is composed of the minerals plagioclase, pyroxene, and olivine.

It is similar to carbon fibre and glass fibre, having better physico-mechanical properties than fibre glass, but being significantly cheaper than carbon fibre. Basalt is mainly used (as crushed rock) in construction, industrial and high way engineering. One can also melt basalt and spin it into fine fibres. Some possible applications of basalt fibres and basalt-based composite are thermal and sound insulation/protection, pipes, insulating plastics and frictional materials.

The production of basalt fibre consists of melt preparation, extrusion, fibre formation, application of lubricates and finally winding. The method is also known as spinning. A fibre is a material made into a long filament with density generally in the order of 300gm/cm^2. The aspect ratio(ratio of length and diameter) can be ranging from thousand to infinity in continuous fibres. It does not undergo any toxic reaction with water and don't pollute the air also. The functions of the fibres are to carry the load and provide stiffness, strength, thermal stability and other structural properties.

2.0 Objective of the work

The main objective of this experimental work is to investigate the behaviour of basalt fibre (chopped strand) reinforced concrete in which the fibres are added from 0% to 2.5% with 0.50% increments. The different strength characteristics studied are, compressive strength, tensile strength, flexural strength, shear strength and impact strength. A design mix of M30 is prepared by using IS 10262:2009. 28 days water curing was adopted for all the testing specimens. Strength characteristics of basalt fibre reinforced concrete are compared with the reference mix (M30 concrete without fibre).

3.0 Materials and methodology

- **Cement**

In the experimental work, Ordinary Portland Cement (OPC) 43 grade conforming to IS: 8112 – 1989 was used.

- **Fine aggregates**

Locally available river sand confirming to zone II of IS: 383–1970 was used for the project work.

- **Coarse aggregates**

Locally available crushed aggregates confirming to IS: 383–1970 were used in this project work.

- **Basalt fibre**

For the experimental work 6mm and 12mm size basalt chopped fibres were used with 50% combination of each size.

Fig. 1: Basalt fibre

- **Mix proportion**

M 30 grade of concrete was designed using IS: 10262-2009 method of mix design. The mix proportion for M 30 grade concrete is given in the table 1

Cement = 478.95 Kg/m^3

Water = 191.58 Kg/m^3
Fine aggregate = 660.59 Kg/m^3
Coarse aggregate = 1037.14 Kg/m^3
W/C = 0.40

Table 1: Mix proportion for M30 grade concrete

Grade of concrete	Cement	Fine aggregate	Coarse aggregate	W/C
M 30	1	1.38	2.17	0.4

4.0 Mixing and casting of specimens

The mixing procedure was done according to the following steps:

- Dry mix the sand and cementitious materials.
- Add required quantity of basalt fibre for the dry mix as per calculations and mix it thoroughly to get homogeneous mix.
- Add coarse aggregate to it and mix it thoroughly to achieve a homogeneous mix.
- Add the calculated quantity of water to the dry mix and mix thoroughly to get a homogeneous wet mix.
- This homogeneous mix is placed in the moulds in three different layers and sufficient compaction was given both by tamping rod and by table vibrator.
- After compaction the specimens were finished smooth and left under wet gunny bags for 24 hours.
- After 24 hours they were demoulded and transferred to curing tank where they were allowed to cure for 28 days.
- After 28 days they were tested for their respective strengths.

5.0 Test results

5.1 Workability test results:

Table 2 gives the various workability test results of basalt fibre reinforced concrete for different percentages of fibres. The variation is represented in the form of graphs.

Table 2: Workability test results

% of basalt fibre by volume fraction	Slump (mm)	Compaction factor	Vee-Bee degree (Sec)	Percentage flow
0.00%	60	0.95	37	6.64
0.50%	57	0.94	43	4.84
1.00%	53	0.93	47	3.9
1.50%	48	0.92	49	3.72
2.00%	45	0.92	53	3.44
2.50%	40	0.91	57	2.67

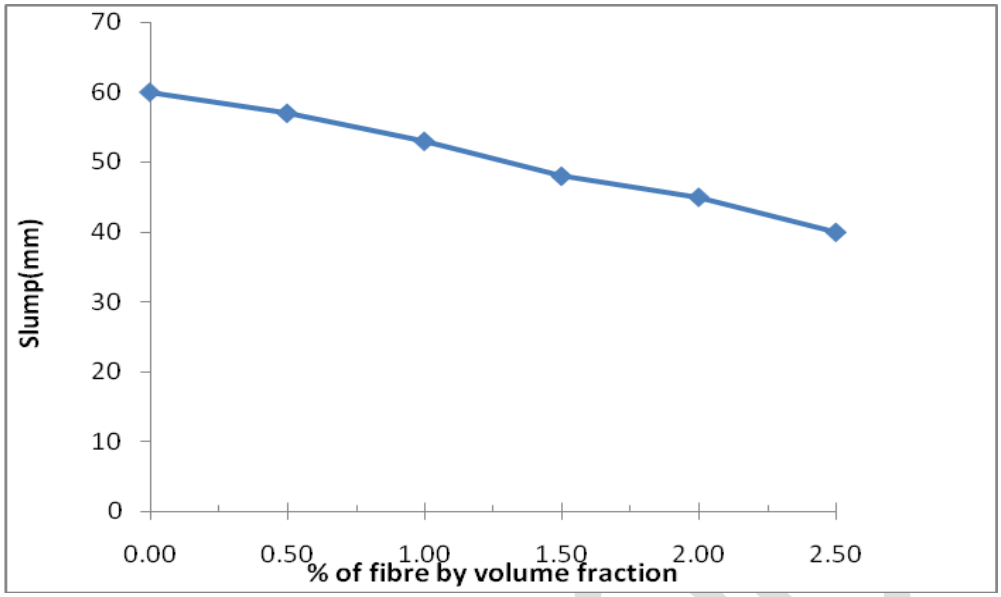

Fig.2: Variation of slump

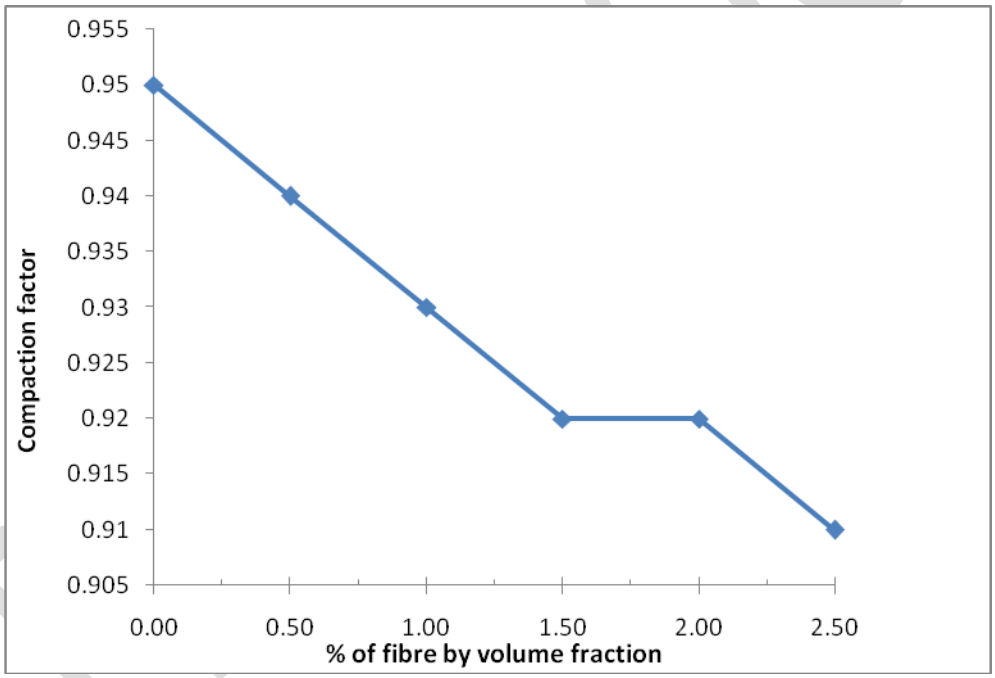

Fig.3: Variation of compaction factor

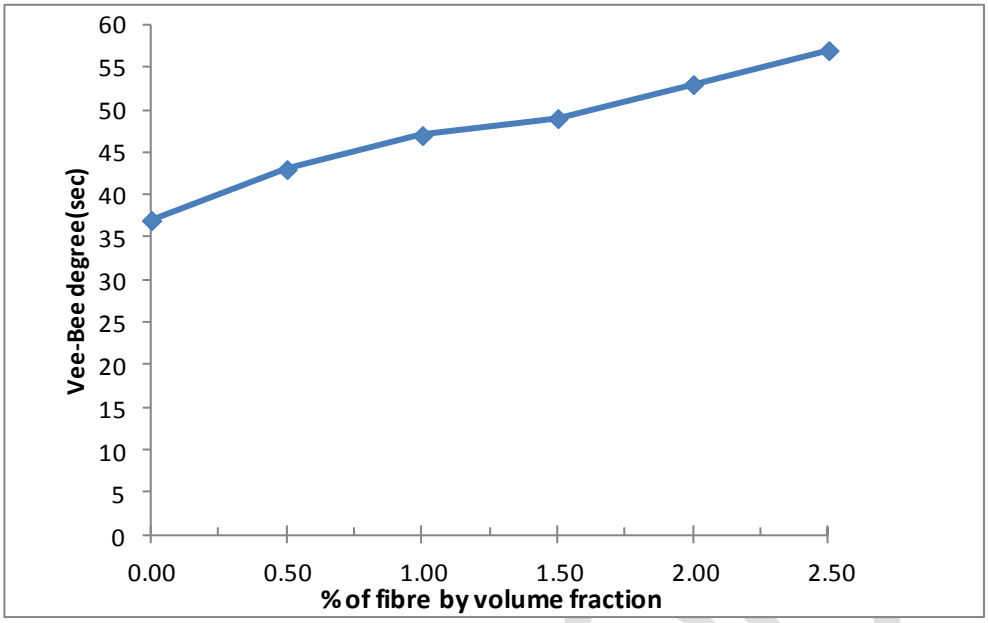

Fig. 4: Variation of Vee-Bee degree

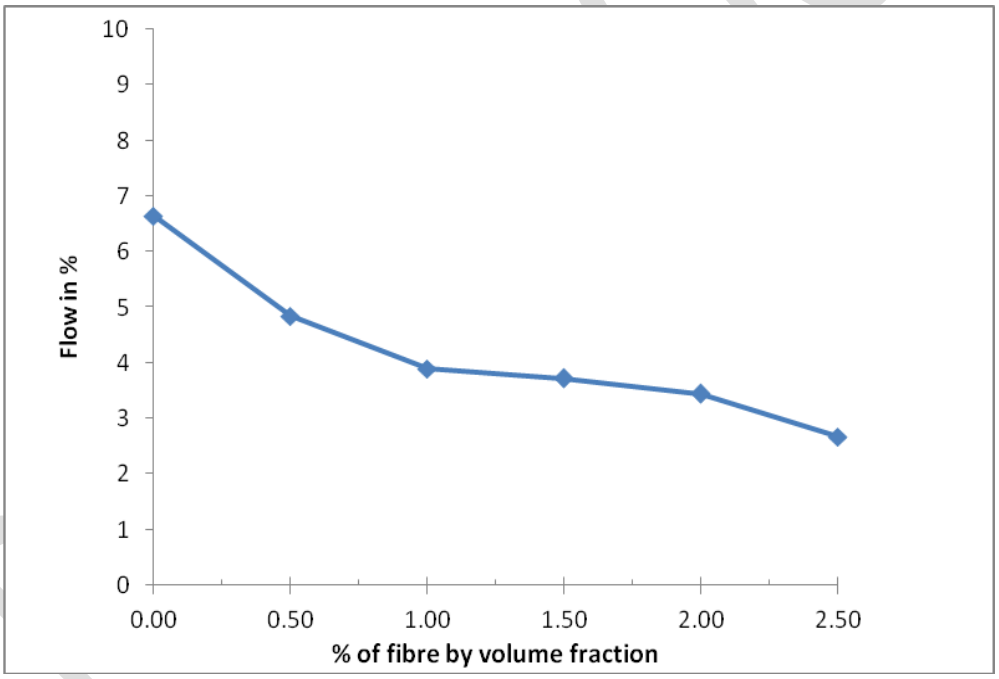

Fig. 5: Variation of percentage of flow

5.2.1 Compressive strength test results

Table 3 gives the 28 days compressive strength test results of concrete produced by adding the basalt fibre in different percentages. The variation of compressive strength is shown in fig 6.

Table 3: Overall results of compressive strength

Percentage of basalt fibres by volume fraction	Compressive strength (MPa)	Percentage increase of compressive strength w.r.t reference mix (%)
0 (Reference mix)	32.89	____
0.5	34.22	4.04
1	36.22	10.12
1.5	37.11	12.83
2	38.67	17.57
2.5	34.22	4.04

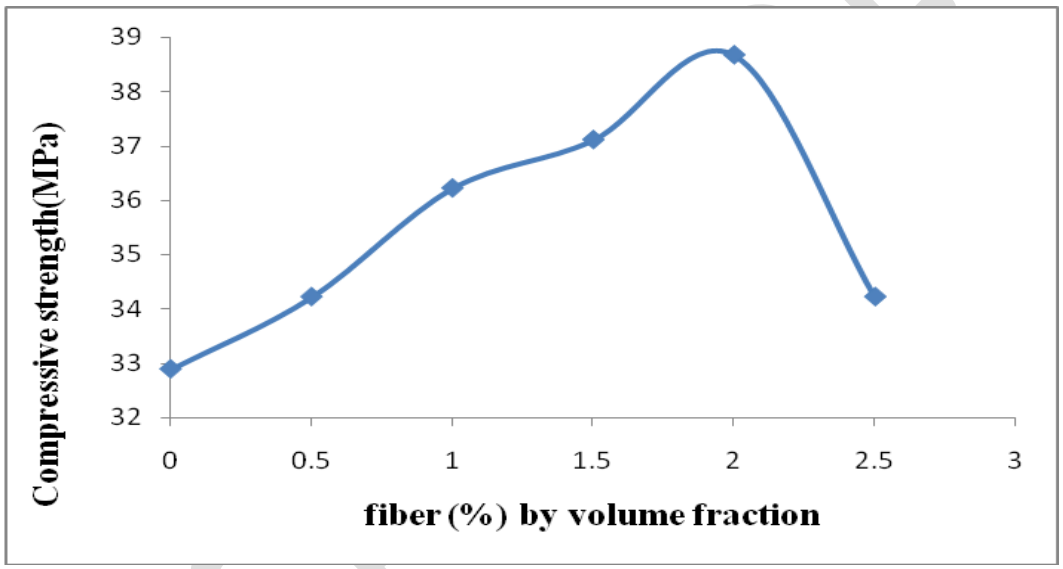

Fig. 6: Variation of compressive strength

5.2.2Tensile strength test results

Table 4 gives the tensile strength test results of concrete produced by adding the basalt fibre in different percentages. The variation of tensile strength is shown in the fig 7

Table 4: Overall results of tensile strength

Percentage of basalt fibres by volume fraction	Tensile strength of concrete (MPa)	Percentage increase of tensile strength w.r.t reference mix (%)
0(Reference mix)	2.26	____
0.5	2.76	22.12
1	3.11	37.61
1.5	3.39	50
2	3.75	65.93
2.5	3.32	46.90

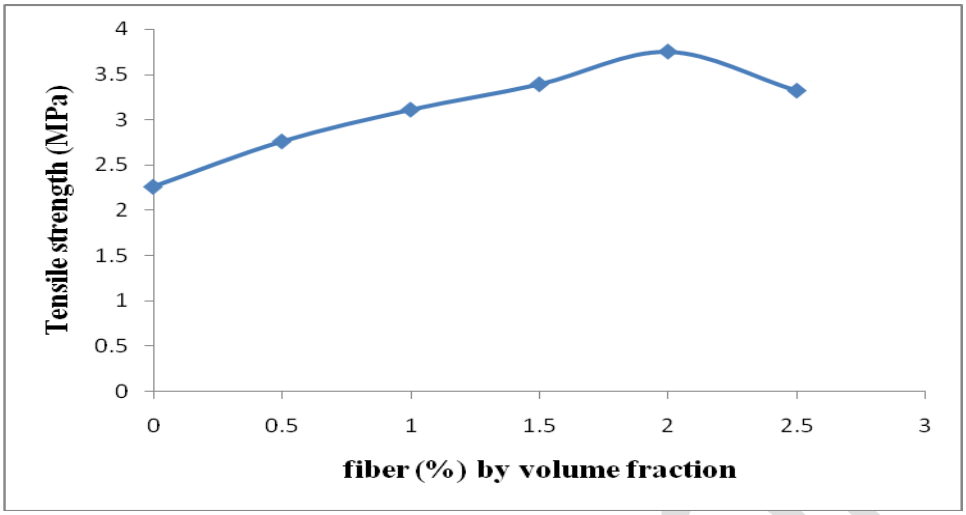

Fig. 7: Variation of tensile strength

5.2.3 Flexural strength test results

Table 5 gives the flexural strength test results of concrete produced by adding the basalt fibre in different percentages. The variation of flexural strength is shown in the fig 8

Table 5: Overall results of flexural strength

Percentage of basalt fibres by volume fraction	Flexural strength of concrete (MPa)	Percentage increase of flexural strength w.r.t reference mix (%)
0 (Reference mix)	3.8	____
0.5	4.6	21.05
1	5.7	50
1.5	6.4	68.42
2	6.8	78.94
2.5	6.5	71.05

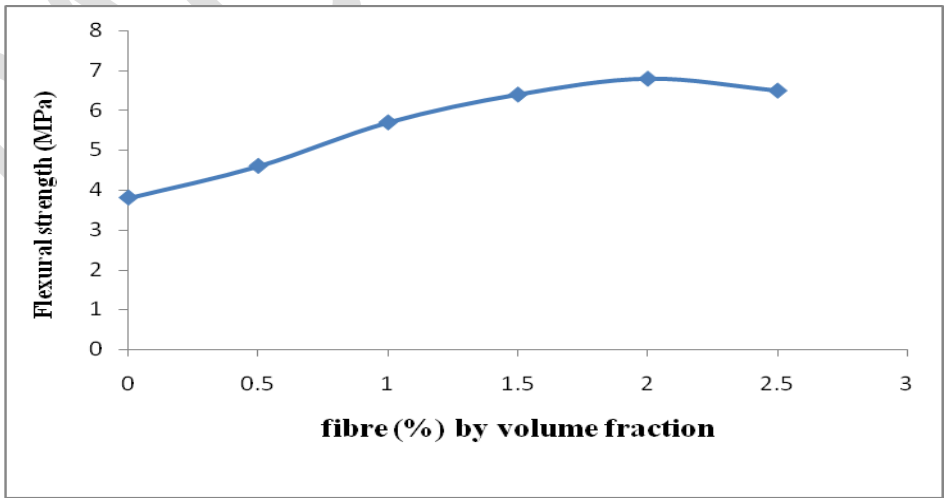

Fig. 8: Variation of flexural strength

5.2.4 Shear strength test results

Table 6 gives the shear strength test results of concrete produced by adding the basalt fibre in different percentages. The variation of shear strength is shown in the fig 9

Table 6: Overall results of shear strength

Percentage of basalt fibres by volume fraction	Shear strength (MPa)	Percentage increase of shear strength w.r.t reference mix(%), (MPa)
0 (Reference mix)	10.28	____
0.5	13.06	27.04
1	16.11	56.71
1.5	18.33	78.31
2	20	94.55
2.5	15.56	51.36

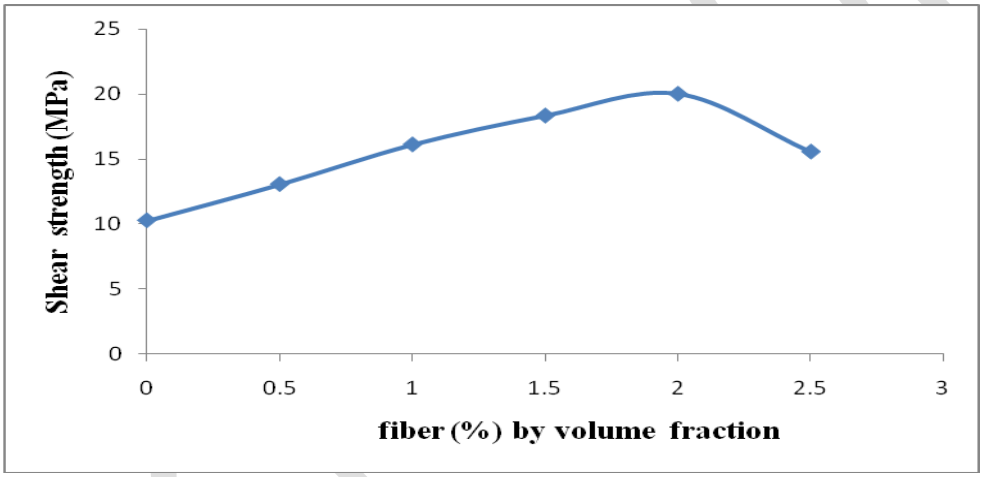

Fig. 9: Variation of shear strength

5.2.5 Impact strength test results

Table 7 gives the impact strength test results of concrete produced by adding the basalt fibre in different percentages. The variation of impact strength is shown in fig 10

Table 7 Overall results of impact strength

Percentage of basalt fibres by volume fraction	Impact strength for first crack (N-m)	Percentage increase of impact strength for first crack w.r.t reference mix	Impact strength for final failure (N-m)	Percentage increase of impact strength for final failure w.r.t reference mix
0 (Reference mix)	250.07	____	302.17	_____
0.5	302.17	20.83	416.78	37.93
1	3063.36	1125.00	3167.56	948.27
1.5	5772.46	2208.34	5970.43	1875.85
2	7116.59	2745.84	7241.62	2296.54
2.5	4876.37	1850.00	5032.67	1565.51

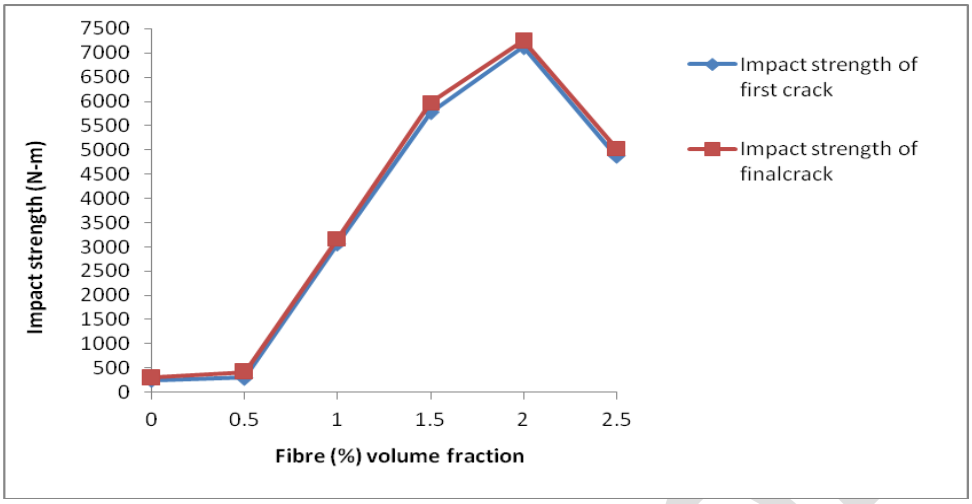

Fig. 10: Variation of impact strength

6.0 Observation And Discussions:

Following observations were made based on the experiments conducted on the strength characteristics of basalt fibre reinforced concrete.

1) It is observed that the workability of concrete as measured from slump, compaction factor, vee-bee degree, %flow for basalt fibre reinforced concrete go on decreasing as the percentage of fibre in it increase. This may be due to the fact that the higher percentage of basalt fibre will obstruct the flow characteristics and hence reduce the workability. Thus it can be concluded that the workability of basalt fibre reinforced concrete decreases as the percentage of fibres in it increases.

2) It is observed that the compressive strength of basalt fibre reinforced concrete goes on increasing up to an addition of 2% basalt fibre. After 2% addition the compressive strength shows a decreasing trend. Thus the higher compressive strength can be obtained by adding 2% basalt fibre in to concrete. At 2% addition of basalt fibre the percentage increase of compressive strength is found to be 17.57%. This may be due to the fact that 2% addition of basalt fibres into concrete may result in uniform dispersion of basalt fibre and hence a homogeneous mix, thereby increasing the compressive strength. Thus it can be concluded that the higher compressive strength of basalt fibre reinforced concrete can be obtained by adding 2% basalt fibres and the percentage increase in compressive strength is 17.57%.

3) It is observed that the tensile strength of basalt fibre reinforced concrete goes on increasing up to an addition of 2% basalt fibre. After 2% addition the tensile strength shows a decreasing trend. Thus the higher tensile strength can be obtained by adding 2% basalt fibre in to concrete. At 2% addition of basalt fibre the percentage increase of tensile strength is found to be 65.93%. This may be due to the fact that 2% addition of basalt fibres into concrete may result in uniform dispersion of basalt fibre and hence a homogeneous mix, thereby increasing the tensile strength. Thus it can be concluded that the higher tensile strength of basalt fibre reinforced concrete can be obtained by adding 2% basalt fibres and the percentage increase in tensile strength is 65.93%.

4) It is observed that the flexure strength of basalt fibre reinforced concrete goes on increasing up to an addition of 2% basalt fibre. After 2% addition the flexure strength shows a decreasing trend. Thus the higher flexure strength can be obtained by adding 2% basalt fibre in to concrete. At 2% addition of basalt fibre the percentage increase of flexure strength is found to be 78.94%. This may be due to the fact that 2% addition of basalt fibres into concrete may result in uniform dispersion of basalt fibre and hence a homogeneous mix, thereby increasing the flexure strength. Thus it can be concluded that the higher flexure strength of basalt fibre reinforced concrete can be obtained by adding 2% basalt fibres and the percentage increase in flexure strength is 78.94%.

5) It is observed that the shear strength of basalt fibre reinforced concrete goes on increasing up to an addition of 2% basalt fibre. After 2% addition the shear strength shows a decreasing trend. Thus the higher shear strength can be obtained by adding 2% basalt fibre in to concrete. At 2% addition of basalt fibre the percentage increase of shear strength is found to be 94.55%.This may be due to the fact that 2% addition of basalt fibres into concrete may result in uniform dispersion of basalt fibre and hence a homogeneous mix, thereby increasing the shear strength. Thus it can be concluded that the higher shear strength of basalt fibre reinforced concrete can be obtained by adding 2% basalt fibres and the percentage increase in shear strength is 94.55%.

6) It is observed that the impact strength of basalt fibre reinforced concrete goes on increasing up to an addition of 2% basalt fibre. After 2% addition the impact strength shows a decreasing trend. Thus the higher impact strength can be obtained by adding 2% basalt fibre in to concrete. At 2% addition of basalt fibre the percentage increase of impact strength is found to be 2296.53%.This may be due to the fact that 2% addition of basalt fibres into concrete may result in uniform dispersion of basalt fibre and hence a homogeneous mix, thereby increasing the impact strength. Thus it can be concluded that the higher impact strength of basalt fibre reinforced concrete can be obtained by adding 2% basalt fibres and the percentage increase in impact strength is 2296.53%.

CONCLUSIONS

- Following conclusions can be drawn based on the study conducted on the strength characteristics of basalt fibre reinforced concrete.
- The workability of basalt fibre reinforced concrete decreases as the percentage of fibres in it increases.
- The higher compressive strength of basalt fibre reinforced concrete can be obtained by adding 2% basalt fibres and the percentage increase in compressive strength is 17.57%.
- The higher tensile strength of basalt fibre reinforced concrete can be obtained by adding 2% basalt fibres and the percentage increase in tensile strength is 65.93%.
- The higher flexure strength of basalt fibre reinforced concrete can be obtained by adding 2% basalt fibres and the percentage increase in flexure strength is 78.94%.
- The higher shear strength of basalt fibre reinforced concrete can be obtained by adding 2% basalt fibres and the percentage increase in shear strength is 94.55%.
- The higher impact strength of basalt fibre reinforced concrete can be obtained by adding 2% basalt fibres and the percentage increase in impact strength is 2296.53%.
- Therefore, it is recommended that 2% of basalt fibres can be added to the concrete for effective strength.

REFERENCES

[1]. Gore Ketan R, Suhasini M. Kulkarni, “The performance of basalt fibre in high strength concrete” Journal of Information, Knowledge and Research in Civil Engineering, Nov 2012 to Oct 2013/ volume 2, issue 2, pp 117 -124.

[2]. Singaravadivelan R, Chinnadurai P, Muthuramu KL and Vincent P. “Flexural behaviour of basalt chopped strands fibre reinforced concrete beams” 2nd International Conference on Chemical, Ecology and Environmental Science. June 17 -18, 2013 London (UK), pp 237 - 241.

[3]. Dymlar Penteado Dias, Clelio Thaumaturgo, “Fracture toughness of geo polymeric concretes reinforced with basalt fibre” Cement and Concrete Composites 27(2005),pp 49-54.

[4]. Nihat Kabay. “Abrasion resistance and fracture energy of concretes with basalt fibre” Construction and Building Materials, 50 (2014) pp 95 – 101.

[5]. Anandakumar R, Selvamony C, Kunnan S.U “Retrofitting of concrete specimens and reinforced concrete Piles Using Basalt fibres” International Journal of Engineering Science Invention ISSN: 2319 – 6734, ISSN:2319 – 6726 Volume 2 Issue 8 August 2013,pp01-05.

[6]. Singaravadivelan R, Chinnadurai P, Muthuramu KL and Ramamoorthy N.V, "An experimental study to Evaluate the Behaviour of Concrete Elements using Basalt Chopped Strands Fibre" International Conference on Chemical, Bio-chemical and Environmental Sciences,(ICBEE' 2012) December 14-15,2012 Singapore. PP 31 - 34.

[7]. IS: 10262 – 2009, "Concrete mix proportioning – Guidelines" (First revision), Bureau of Indian Standards, Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi, July2009.

[8]. IS: 456 – 2000, "Plain and reinforced concrete – Code of practice" (Fourth revision), Bureau of Indian Standards, Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi, October 2000.

[9]. IS: 8112 – 1989, "43 Grade ordinary Portland cement—Specifications" (First revision), Bureau of Indian Standards, Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi, May 1990.

[10]. IS: 383 – 1970, "Specifications for coarse and fine aggregate from natural sources for concrete" (Second revision), Bureau of Indian Standards, Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi, April 1971.

[11]. IS: 3812 (Part 1) – 2003, "Pulverized fuel ash – Specification" (Second revision), Bureau of Indian Standards, Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi, October 2003.

[12]. IS: 5816 – 1999, "Splitting tensile strength of concrete – Method of test" (First revision), Bureau of Indian Standards, Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi, July 1999.